PIBS #557 E

GUIDELINES FOR ROAD TRAFFIC NOISE ASSESSMENT

DECEMBER, 1986

Ontario
Ministry of the Environment

GUIDELINES

FOR

ROAD TRAFFIC NOISE ASSESSMENT

ONTARIO MINISTRY OF THE ENVIRONMENT
ENVIRONMENTAL APPROVALS AND LAND USE PLANNING BRANCH
DECEMBER 1986

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1 INTRODUCTION

This report is a simplified guideline manual for the prediction of road traffic noise. It presents the procedure required by this Ministry for the prediction of equivalent sound levels, L_{eq}, due to road traffic. This procedure is to be used for land use planning, approvals of new installations or abatement.*

The prediction model is based on an enhanced and simplified version of a procedure developed by the U.S. Federal Highway Administration.** Results of studies conducted to determine the prediction accuracy of the model on Ontario roadways have indicated that, within the limitations described in Section 4, the average difference between the measured and predicted sound levels is about 2 dBA.

The manual is structured in the following manner:

> Sections 2 and 3 contain step-by-step instructions on the method used to calculate sound levels due to road traffic.
>
> Section 4 contains limitations of the prediction model in terms of traffic speed, distance, volume and topography.
>
> The final section contains a sample calculation. The calculation is performed through the use of tables and traffic noise prediction worksheets.

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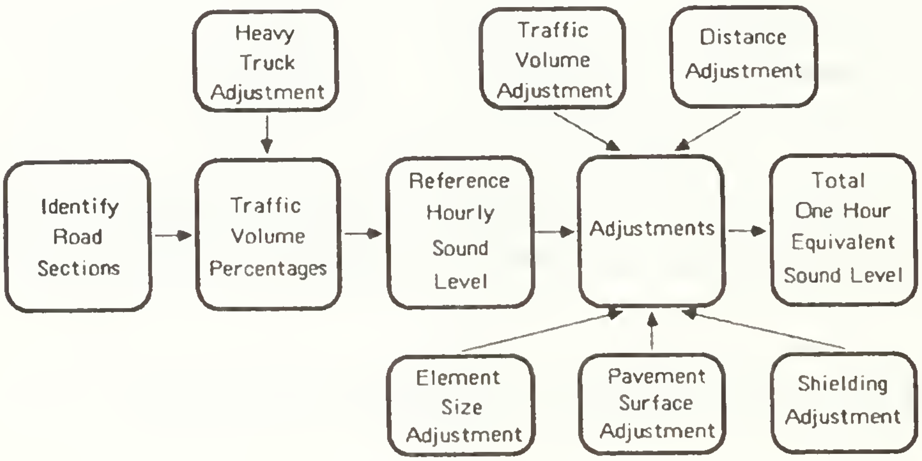
* In complex situations involving multiple roadways, multiple shielding mechanisms and/or varying topography, it is more appropriate to utilize a computer program available from the Noise Assessment Unit, Ministry of the Environment.

** Bibliography and theoretical background are contained in a separate document.

2 TRAFFIC SOUND LEVEL FOR A SINGLE ROADWAY

The following procedure shall be used to calculate the One Hour Equivalent Sound Level at a point of reception due to traffic on a single roadway. The tables used in the calculations are contained in Appendix A.

Procedure Summary



2.1 Identification of Road Sections (Elements)

(a) Where a roadway extends for large distances on either side of the point of reception, the calculation shall assume that the roadway extends, in each direction, at least six times the perpendicular distance from the point of reception to the roadway centre.

(b) A roadway of less than four lanes shall be represented by a series of straight line sections along its centre.

A roadway having a total of four lanes or more shall be divided into one or more sets of lanes for each direction of traffic flow. A maximum number of four lanes should be included in one set. Each set of lanes shall then be

represented by a series of straight line sections along its centre.

(c) A section of road shall be as long as possible but short enough to ensure that the following variables are approximately constant along its length:

- road alignment;
- road gradient (if heavy trucks are present);
- pavement surface type;
- traffic flow conditions:
  - ° total traffic volume
  - ° traffic composition
  - ° posted speed limit
- attenuation mechanisms:
  - ° ground absorption
  - ° shielding

2.2 Sound Level from a Single Road Section (Element)

The following calculations shall be used to determine the One Hour Equivalent Sound Level contribution from each road section. The method employed in deriving one hour traffic volumes from average daily traffic volumes is described in Appendix C.

(a) Traffic Volume

Traffic volumes can be obtained from the following sources:

(i) Annual MTC Reports, "Provincial Highways, Traffic Volumes" published by the Highway Program Planning Office, and "Commercial Vehicle Travel Data" published by the Transportation Demand Research Office.

(ii) Traffic Department of the local municipal office.

(iii) Individual Traffic Volume Count. Vehicles shall be counted for at least 20 minutes and the time interval of observation shall be noted. The total traffic volume, in vehicles per hour, is the number of vehicles counted divided by the time interval represented as a fraction of an hour.

If the total one hour traffic volume based on a traffic count of at least 20 minutes is less than 40 vehicles per hour, vehicles shall be counted for the full one hour period. If the full hour count is still less than 40 vehicles, this noise prediction method is not to be used.

The vehicles considered shall be placed into one of the following categories:

- Automobiles - all vehicles having two axles and four wheels designed primarily for transportation of nine or fewer passengers or transportation of light cargo (e.g. vans, light trucks). Generally, the gross vehicle weight is less than 4500 kilograms.

- Medium trucks - all vehicles having two axles and six wheels. Generally, the gross vehicle weight is greater than 4500 kilograms but less than 12,000 kilograms.

- Heavy trucks - all vehicles having three or more axles and designed for the transportation of cargo. Generally, the gross vehicle weight is greater than 12,000 kilograms. (Buses, although two axle vehicles, are included in this category).

(b) Adjusted Volume of Heavy Trucks

The adjustment shall be made by multiplying the percentage of heavy trucks travelling in the up-grade direction by an adjustment factor given in Table 1. The adjustment shall be applied only where the total vertical distance from the bottom to the top of the grade is at least 6 metres, and on roads having gradients of 2% or more. The adjusted percentage of heavy trucks shall then be converted to an adjusted volume.

(c) Percentage Trucks (Medium + Heavy)

The combined volume of vehicles classified as medium trucks and heavy trucks (adjusted if required) shall be expressed as a percentage of the total hourly traffic volume which was determined in Subsection 2.2(a).

(d) Percentage of Medium Trucks

The volume of vehicles classified as medium trucks shall be expressed as a percentage of the total volume of trucks (medium and heavy) determined in Subsection 2.2(c).

(e) Reference Hourly Sound Level

The Reference Hourly Sound Level at the reference distance of 15 metres from the centreline of the road section and the reference volume of 40 vehicles per hour shall be determined using Tables 3 through 6. Where the actual percentage of trucks (medium + heavy) is not provided, the nearest value shall be used.

(f) Measurement of Distance

The distance (in metres) between the point of reception and the centreline of the road section shall be measured along the shortest line joining the point of reception to the centre of the road section or its extension.

(g) Adjustments

The following adjustments shall be made to the Reference Hourly Sound Level.

(i) Adjustment for Traffic Volume

Table 2 gives the adjustment for traffic volume to be added to the Reference Hourly Sound Level.

(ii) Adjustment for Distance

Table 7 shall be used to adjust for distance and for the type of ground surface between the point of reception and the centreline of the road section.

"Reflective Surfaces"

Water, ice, asphalt, gravel, earth or other hard-packed surfaces are sound reflective.

If more than half of the ground surface between the centreline of the road section and the point of reception is sound reflective, the adjustment for distance and for the type of ground surface shall be determined using the section of Table 7 for Reflective Surfaces. The adjustment shall be added to the Reference Hourly Sound Level.

"Other Surfaces (Non-Reflective)"

If less than half of the ground surface between the centreline of the road section and the point of reception is sound reflective, the adjustment shall be dependent on the total effective height. The total effective height shall be determined by adding together the height of the point of reception above the ground, the effective height of shielding between the source and the receptor, (typical situations shown in Table 7), and the effective source height of road traffic obtained from Table 8. The adjustment shall be determined using the section of Table 7 for Non-Reflective Surfaces and shall be added to the Reference Hourly Sound Level.

(iii) Adjustment for Road Element Size

The adjustment for road element size is based on the angle subtended at the point of reception by the roadway section, see Table 10. The adjustment for road element size will also be dependent on the major type of ground surface within the sector.

"Reflective Surfaces"
Table 9 shall be used to determine the adjustment for road element size if more than half of the ground surface within the sector is sound reflective. The adjustment shall be added to the Reference Hourly Sound Level.

"Other Surfaces (Non-Reflective)"
Adjustment for Non-Reflective surfaces is considered only if the total effective height is less than 10 m. If the total effective height equals or exceeds 10 m or a barrier separates road element from receptor, adjustment in Table 9 applies.

Table 10 shall be used to determine the angular relationship between the road section and the point of reception. Adjustments for various combinations of angles can be determined from Table 11. The adjustment shall be added to the Reference Hourly Sound Level.

The minimum value of the adjustment equals -1 dBA which corresponds to a subtended angle of 180°.

(iv) Adjustment for Pavement Surface Type

An adjustment for the effect of road pavement surface shall be applied only on road sections having posted speed limits equal to or greater than 80 km/h. The adjustment shall be obtained from Table 12.

(v) Adjustments for Shielding

Shielding can be provided by vegetation, rows of houses or by a solid obstacle (barrier).

Dense Woods*

An adjustment for the attenuation by trees shall be made if and only if the woods are very dense, i.e. there is no visual path between the receiver and the road section (may not hold for deciduous trees in winter), and if the trees extend at least 5 metres above the line-of-sight. Table 13 gives the adjustment for shielding provided by dense woods.

Rows of Houses*

Table 13 gives the adjustment for shielding provided by rows of houses.

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* When a receiver is shielded by dense woods or rows of houses, the ground surface must be considered "reflective".

Barriers**

Appendix B shall be used to obtain the adjustment for attenuation provided by any solid obstacle.

Combined Shielding Mechanisms

Where several types of shielding exist, the adjustments are additive up to a maximum attenuation of 20 dBA. In addition, the combined effects of dense woods and rows of houses are only additive up to a maximum of 10 dBA.

(h) Resultant Sound Level Contribution

The One Hour Equivalent Sound Level at the point of reception due to traffic on a road section is the Reference Hourly Sound Level as determined in 2.2(e) and adjusted according to 2.2(g).

2.3 Determination of Total Sound Level

The total One Hour Equivalent Sound Level at the point of reception due to traffic on a single roadway shall be determined by combining the sound level contributions from each road section using the rule for addition of sound levels in Table 14.

** Where two or more barriers intersect the line-of-sight between the source and receiver, it is a conservative practice to employ only the most effective barrier.

3 TRAFFIC SOUND LEVEL FOR MULTIPLE ROADS

The One Hour Equivalent Sound Level at a point of reception due to traffic on multiple roads shall be calculated by combining the sound levels resulting from each individual roadway as per Section 2. The individual One Hour Equivalent Sound Levels from the contributing roads shall be combined using the rule for addition of sound levels in Table 14.

4 LIMITATIONS

The method for prediction of traffic noise described herein is not applicable when:

(i) The distance from the point of reception to the centreline of any road section is less than 10 m.

(ii) The posted speed limit of traffic is less than 40 km/h.

(iii) The hourly traffic volume is less than 40 vehicles per hour.

In addition, the prediction accuracy may decrease where:

- the topography is very irregular (e.g. many different intervening man-made or natural obstructions or substantial variations in ground cover);
- the distance from the point of reception to the centreline of any road section is less than 15 m;

- the roadway has substantial variations in alignment (horizontal/vertical) or pavement surface;

- the roadway features interchanges/intersections, ramps, etc;

- substantial differences exist between the speeds of cars, medium trucks and heavy trucks.

- posted speed limit is less than 50 km/h.

It is advisible to use a comprehensive noise prediction model in the above specified cases.

5 SAMPLE CALCULATIONS

This section contains sample calculations of the One Hour Equivalent Sound Level, Leq(h), generated by road traffic. The calculations were performed through the use of tables and noise prediction work sheets.

PROBLEM

Refer to Figure 1. Using the information provided, determine the One Hour Equivalent Sound Levels, $L_{eq}(h)$, at the receiver due to traffic on the highway before and after barrier construction.

The road is flat (no gradient), infinitely long and paved with typical asphalt. The road and the surrounding terrain are at the same grade; the ground is non-reflective. The receiver is located 1.5 metres above ground. The barrier is 3 metres high.

SOLUTION

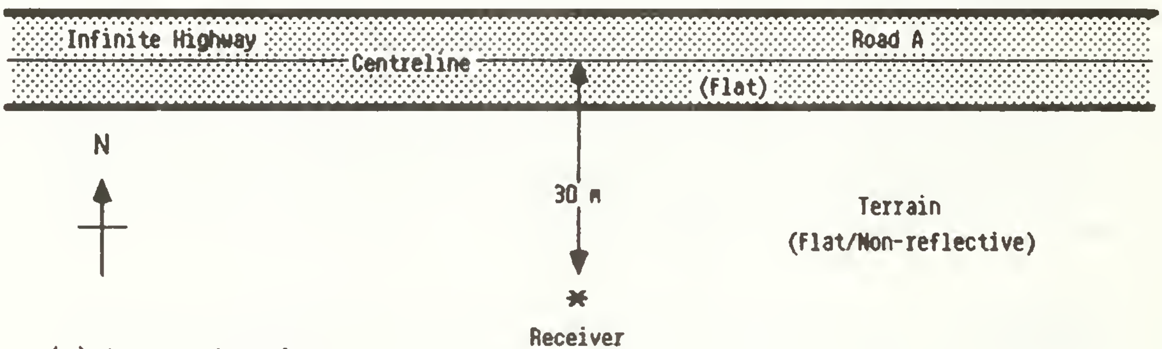
The traffic sound levels before and after the barrier is constructed have been calculated on separate work sheets. Refer to Figures 2 and 3.

5.1 Before Barrier Sound Level

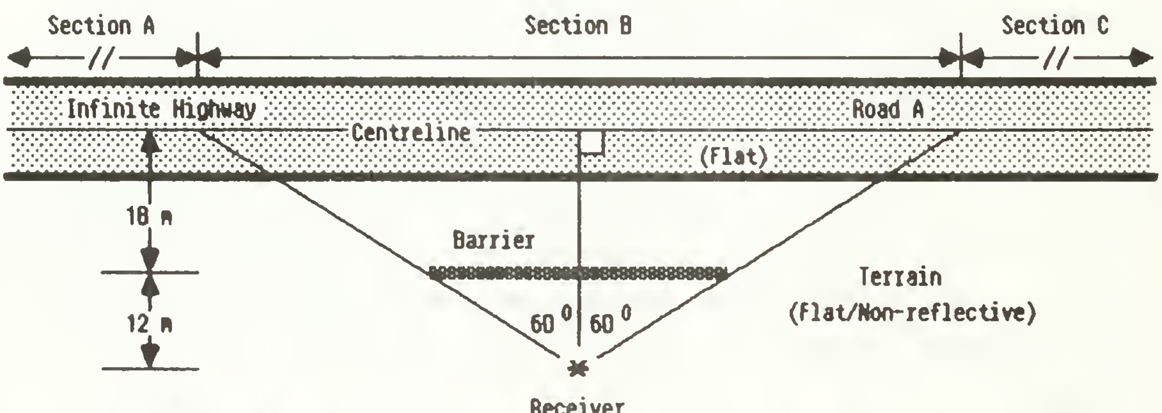
STEP 1. Since the traffic flow conditions and the characteristics of the road and of the surrounding terrain are uniform along the length of the highway under consideration, the road need not be divided into sections. Enter the appropriate lane designations for the two-lane highway on Line 1.

FIGURE 1

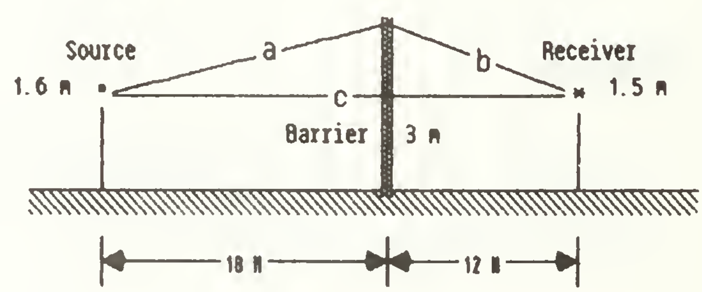
Conditions On Site



(A) Before Barrier



(1) Plan View



(2) Elevation View

(B) After Barrier

Vehicles Per Hour			Posted Speed (km/h)
Passenger Cars	Medium Trucks	Heavy Trucks	
910	20	70	80

(C) Traffic Data

FIGURE 2 Sample Calculation - Before Barrier

Name J. Smith Date May 5, 1986 File LU - 5001 Project Description Road A - Before Barrier

			Road A											
1	Lanes/Road Section (Element)		EB and WB											
2	Volume -Automobiles (vph)	S 2.2(a)	910											
3	Medium Trucks (vph)		20											
4	Heavy Trucks (vph)		70											
5	Total Volume (vph)		1000											
6	Posted Speed (km/h)		80											
7	Heavy Trucks (%)		7											
	Adjusted Heavy Trucks	S 2.2(b)												
8	Road Gradient (%)		0											
9	Adjustment Factor	Table 1												
10	Adjusted Volume (vph)													
11	Medium & Heavy Trucks (%)	S 2.2(c)	9											
12	Medium Trucks (%)	S 2.2(d)	22											
13	Reference Sound Level (dBA)	Tables 3-6		59										
	Effective Heights													
14	Source (s) (m)	Table 8	1.6											
15	Receiver (r) (m)		1.5											
16	Shielding (t+p) (m)	Table 7												
17	Total Effective Height (m)	Table 7	3.1											
	Adjustments													
18	Volume (dBA)	Table 2		14										
19	Distance (m)		30											
20	Reflective (dBA)	Table 7												
21	Non-reflective (dBA)	Table 7		-5										
22	Element, θ_1 (degrees)		-90											
23	θ_2 (degrees)		90											
24	Reflective (dBA)	Table 9												
25	Non-reflective (dBA)	Table 11		-1										
26	Pavement Surface (dBA)	Table 12		0										
27	Woods (dBA)	Table 13												
28	Rows Of Houses (dBA)	Table 13												
	Barrier Shielding													
29	θ_1 (degrees)													
30	θ_2 (degrees)													
31	Finite Barrier Index	Table B1												
32	Path Length Difference(m)	Table B2												
33	Barrier Attenuation (dBA)	Table B2												
34	Section Leq(h) (dBA)			67										
35	Road Leq(h) (dBA)	Table 14		67										

FIGURE 3 Sample Calculation - After Barrier

e J. Smith Date May 5, 1986 File LU - 5001 Project Description Road A - After Barrier

		Section A				Section B				Section C			
Lanes/Road Section (Element)		EB and WB				EB and WB				EB and WB			
Volume -Automobiles (vph)	S 2.2(a)	910				910				910			
Medium Trucks (vph)		20				20				20			
Heavy Trucks (vph)		70				70				70			
Total Volume (vph)		1000				1000				1000			
Posted Speed (km/h)		80				80				80			
Heavy Trucks (%)		7				7				7			
Adjusted Heavy Trucks	S 2.2(b)												
Road Gradient (%)		0				0				0			
Adjustment Factor	Table 1												
Adjusted Volume (vph)													
Medium & Heavy Trucks (%)	S 2.2(c)	9				9				9			
Medium Trucks (%)	S 2.2(d)	22				22				22			
Reference Sound Level (dBA)	Tables 3-6		59				59				59		
Effective Heights													
Source (s) (m)	Table 8	1.6				1.6				1.6			
Receiver (r) (m)		1.5				1.5				1.5			
Shielding (t+p) (m)	Table 7					6							
Total Effective Height (m)	Table 7	3.1				9.1				3.1			
Adjustments													
Volume (dBA)	Table 2		14				14				14		
Distance (m)		30				30				30			
Reflective (dBA)	Table 7												
Non-reflective (dBA)	Table 7		-5				-3				-5		
Element, θ_1 (degrees)		-90				-60				60			
θ_2 (degrees)		-60				60				90			
Reflective (dBA)	Table 9						-2						
Non-reflective (dBA)	Table 11		-11								-11		
Pavement Surface (dBA)	Table 12		0				0				0		
Woods (dBA)	Table 13												
Rows Of Houses (dBA)	Table 13												
Barrier Shielding													
θ_1 (degrees)						-60							
θ_2 (degrees)						60							
Finite Barrier Index	Table B1					20							
Path Length Difference(m)	Table B2					.148							
Barrier Attenuation (dBA)	Table B2						-9						
Section Leq(h) (dBA)			57				59				57		
Road Leq(h) (dBA)	Table 14							62.5					

STEP 2. Complete Lines 2-6 and 8 from the data given in the problem statement. Complete Line 7. The heavy trucks are expressed as a percentage of total volume.

STEP 3. Determine the adjustment factor for heavy trucks on up-hill grades from Table 1. Enter the adjustment factor on Line 9 and the adjusted volume on Line 10. In the given sample calculation, the road gradient is 0% and no adjustment is required.

STEP 4. Calculate the percentage trucks (medium + heavy) (9%) as per section 2.2 (c) and enter on Line 11.

Calculate the percentage of medium trucks (22%) as per Section 2.2 (d) and enter on Line 12.

STEP 5. Determine the Reference Sound Level from Table 3, using the data shown on Lines 6, 11, and 12. Enter this reference level (59 dBA) on Line 13.

STEP 6. Determine the Effective Source Height (1.6 m) from Table 8 and enter on Line 14. Enter the Receiver Height (1.5 m) on Line 15. Enter the Total Effective Height (1.6 m + 1.5 m) on Line 17.

STEP 7. Determine the adjustment for volume from Table 2, using the volume of 1000 vehicles shown on Line 5. Enter this adjustment (14 dBA) on Line 18.

STEP 8. Complete Line 19 (30 m). Determine the adjustment for distance from the section of Table 7 for non-reflective surfaces using the data shown on Lines 17 and 19. Enter the adjustment (-5 dBA) on Line 21.

STEP 9. Refer to Table 10 and determine the angles ϕ_1 and ϕ_2. Enter $\phi_1 = -90°$ and $\phi_2 = +90°$ on Lines 22 and 23.

Determine the adjustment (-1 dBA) for road element size from Table 11 and enter on Line 25.

STEP 10. Determine the adjustment (0 dBA) for pavement surface type from Table 12 and enter on Line 26.

STEP 11. Calculate the resultant sound level, $L_{eq}(h)$ (67 dBA) and enter on Lines 34 and 35.

5.2 After Barrier Sound Level

STEP 1. As shown in Figure 1, due to the finite barrier, the highway must be divided into three sections. Refer to Table 10 and determine ϕ_1 and ϕ_2 for each section.

(i) Section A $\phi_1 = -90°$, $\phi_2 = -60°$

(ii) Section B $\phi_1 = -60°$, $\phi_2 = +60°$

(iii) Section C $\phi_1 = +60°$, $\phi_2 = +90°$

STEP 2. Enter the appropriate lane designations for Sections A, B and C on Line 1.

STEP 3. For each road section complete Lines 2-15. The entries are identical to those recorded in Section 5.1.

(i) Section A

STEP 1. Complete Lines 17-21 and 26. The entries are identical to those recorded in Section 5.1.

STEP 2. Enter $\phi_1 = -90°$ and $\phi_2 = -60°$ on Lines 22 and 23. Determine the adjustment (-11 dBA) for road element size from Table 11 and enter on Line 25.

STEP 3. Calculate the resultant sound level Leq(h) (57 dBA) and enter on Line 34.

(ii) Section B

STEP 1. Refer to Table 7 and enter the effective height of shielding (t + p = 6 m) on Line 16. Determine the Total Effective Height (9.1 m) and enter on Line 17.

STEP 2. Complete Lines 18, 19 and 26. The entries are identical to those recorded in Section 5.1.

STEP 3. Determine the adjustment (-3 dBA) for distance from Table 7 using the data shown on Lines 17 and 19. Enter the adjustment on Line 21.

STEP 4. Enter ϕ_1 = -60° and ϕ_2 = + 60° on Lines 22 and 23. Determine the adjustment (-2 dBA) for road element size from Table 9 and enter on Line 24.

STEP 5. Enter ϕ_1 = 60° and ϕ_2 = +60° on Lines 29 and 30. Determine the Finite Barrier Index (20) from Table B1 and enter on Line 31.

Determine the Path Length Difference (0.148 m) using the figure and formula in Table B2 and enter on Line 32.

Determine the Barrier Attenuation (-9 dBA) from Table B2 and enter on Line 33.

STEP 6. Calculate the resultant sound level Leq(h) (59 dBA) and enter on Line 34.

(iii) Section C

STEP 1. Complete Lines 17-21 and 26. The entries are identical to those recorded in Section 5.1.

STEP 2. Enter $\emptyset_1 = +60°$ and $\emptyset_2 = +90°$ on Lines 22 and 23. Determine the adjustment (-11 dBA) for road element size from Table 11 and enter on Line 25.

STEP 3. Calculate the resultant sound level Leq(h) (57 dBA) and enter on Line 34.

(iv) <u>Combined Sound Level</u>

Calculate the combined Leq(h) (62.5 dBA) for road Sections A, B and C using the rule for addition of sound levels in Table 14. Enter the road $L_{eq}(h)$ on Line 35.

5.3 Barrier Insertion Loss

The net reduction in the traffic sound level provided by a barrier is called the Barrier Insertion Loss (BIL), i.e.

BIL = Level (Before) - Level (After)

In this problem, the barrier insertion loss is 4.5 dBA (67 - 62.5).

<u>Note</u>: The barrier attenuation and the barrier insertion loss are identical only if (a) the barrier shields the entire roadway and (b) the ground surface between the source and the receiver is "sound reflective".

APPENDIX A

TRAFFIC NOISE PREDICTION TABLES

TABLE 1

Adjustment to Percentage of Heavy Trucks on Up-Hill Grades

Road Gradient %	Adjustment Factor (Multiplicative)
0 to less than 2	1
2 to less than 5	1.5
5 to less than 7	2
Over 7	3

TABLE 2

Adjustment to the Reference Hourly Sound Level for Traffic Volume

Use the nearest listed value when the actual value of volume is not listed.

Hourly Traffic Volume	Adjustment (Additive) dBA	Hourly Traffic Volume	Adjustment (Additive) dBA	Hourly Traffic Volume	Adjustment (Additive) dBA
40	0	315	9	2000	17
50	1	400	10	2500	18
63	2	500	11	3150	19
80	3	630	12	4000	20
100	4	800	13	5000	21
125	5	1000	14	6300	22
160	6	1250	15	8000	23
200	7	1600	16	10000	24
250	8				

Given the posted speed limit of traffic in km/h and the total percentage of trucks (including medium and heavy trucks), the following Tables 3 and 4 provide the predicted Reference Hourly Sound Level at 15 m from the centreline of a road section with a total traffic volume of 40 vehicles per hour (vph). Use the nearest listed value when the actual value of speed or truck percentage is not listed.

TABLE 3

Reference Hourly Sound Level in dBA at 15 m and 40 vph:
Percentage of Medium Trucks in the Range of 0 - 25 %.

POSTED SPEED km/h	PERCENTAGE TRUCKS (MEDIUM+HEAVY)													
	1	2	4	6	9	12	16	21	26	35	45	60	80	100
40	48	49	51	53	54	55	57	58	59	60	61	62	63	64
50	50	51	53	54	56	57	58	59	60	61	62	63	65	66
60	52	53	55	56	57	58	59	60	61	62	63	65	66	67
70	54	55	56	57	58	59	60	61	62	63	65	66	67	68
80	55	56	57	58	59	60	61	62	63	64	65	67	68	69
90	56	57	58	59	60	61	62	63	64	65	66	67	69	69
100	57	58	59	60	61	62	63	64	65	66	67	68	69	70

TABLE 4

Reference Hourly Sound Level in dBA at 15 m and 40 vph:
Percentage of Medium Trucks in the Range of 26 - 50 %.

POSTED SPEED km/h	PERCENTAGE TRUCKS (MEDIUM+HEAVY)													
	1	2	4	6	9	12	16	21	26	35	45	60	80	100
40	47	49	51	52	53	54	56	57	57	59	60	61	62	63
50	50	51	53	54	55	56	57	58	59	60	61	62	64	65
60	52	53	54	55	56	57	59	60	60	62	63	64	65	66
70	53	54	56	57	58	59	60	61	61	63	64	65	66	67
80	55	56	57	58	59	60	61	62	62	64	65	66	67	68
90	56	57	58	59	60	61	62	63	63	65	65	67	68	69
100	57	58	59	60	61	62	63	63	64	65	66	67	69	69

Given the posted speed limit of traffic in km/h and the total percentage of trucks (including medium and heavy trucks), the following Tables 5 and 6 provide the predicted Reference Hourly Sound Level at 15 m from the centreline of a road section with a total traffic volume of 40 vehicles per hour (vph). Use the nearest value when the actual value of speed or truck percentage is not listed.

TABLE 5

Reference Hourly Sound Level in dBA at 15 m and 40 vph: Percentage of Medium Trucks in the Range of 51 - 75 %.

POSTED SPEED km/h	PERCENTAGE TRUCKS (MEDIUM+HEAVY)													
	1	2	4	6	9	12	16	21	26	35	45	60	80	100
40	47	48	50	51	52	53	54	55	56	57	58	59	61	62
50	49	50	52	53	54	55	56	57	58	59	60	61	62	63
60	51	52	53	54	56	56	57	58	59	60	61	63	64	65
70	53	54	55	56	57	58	59	60	60	62	63	64	65	66
80	55	55	56	57	58	59	60	61	62	63	64	65	66	67
90	56	57	58	58	59	60	61	62	63	64	65	66	67	68
100	57	58	59	59	60	61	62	63	63	65	65	67	68	69

TABLE 6

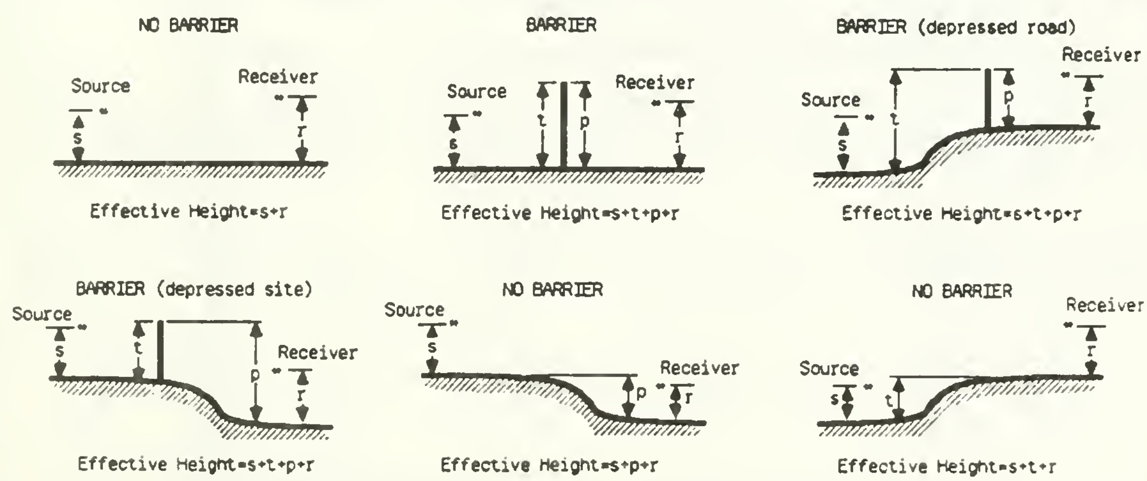
Reference Hourly Sound Level in dBA at 15 m and 40 vph: Percentage of Medium Trucks in the Range of 76 - 100 %.

POSTED SPEED km/h	PERCENTAGE TRUCKS (MEDIUM+HEAVY)													
	1	2	4	6	9	12	16	21	26	35	45	60	80	100
40	46	47	48	49	50	51	52	53	54	55	56	57	58	59
50	49	50	51	52	53	53	54	55	56	57	58	59	60	61
60	51	52	53	53	54	55	56	57	58	59	60	61	62	63
70	53	53	54	55	56	57	58	58	59	60	61	62	63	64
80	54	55	56	56	57	58	59	60	60	61	62	64	65	66
90	56	56	57	58	59	59	60	61	62	63	64	65	66	67
100	57	57	58	59	60	60	61	62	63	64	65	66	67	68

TABLE 7

Adjustment for Distance from Centreline of Road to Point of Reception

Total Effective Height (m)	Perpendicular Distance from Centreline of Road to Point of Reception (m)													
	10*	15	20	30	40	50	60	80	100	120	150	200	250	500
	Adjustment in dBA for Reflective Surfaces													
All Heights	2	0	-1	-3	-4	-5	-6	-7	-8	-9	-10	-11	-12	-15
Height	Adjustment in dBA for Non-Reflective Surfaces													
1.5	3	0	-2	-5	-6	-8	-9	-11	-12	-14	-15	-17	-18	-23
2	3	0	-2	-5	-6	-8	-9	-11	-12	-14	-15	-17	-18	-23
3	3	0	-2	-5	-6	-8	-9	-11	-12	-14	-15	-17	-18	-23
4	3	0	-2	-4	-6	-7	-9	-10	-12	-13	-14	-16	-17	-22
6	2	0	-2	-4	-5	-7	-8	-9	-11	-12	-13	-14	-16	-20
8	2	0	-1	-3	-5	-6	-7	-8	-9	-10	-11	-13	-14	-17
10	2	0	-1	-3	-4	-5	-6	-7	-8	-9	-10	-11	-12	-15
12	2	0	-1	-3	-4	-5	-6	-7	-8	-9	-10	-11	-12	-15
16	2	0	-1	-3	-4	-5	-6	-7	-8	-9	-10	-11	-12	-15
20	2	0	-1	-3	-4	-5	-6	-7	-8	-9	-10	-11	-12	-15
25	2	0	-1	-3	-4	-5	-6	-7	-8	-9	-10	-11	-12	-15
32	2	0	-1	-3	-4	-5	-6	-7	-8	-9	-10	-11	-12	-15
40	2	0	-1	-3	-4	-5	-6	-7	-8	-9	-10	-11	-12	-15
50	2	0	-1	-3	-4	-5	-6	-7	-8	-9	-10	-11	-12	-15
60	2	0	-1	-3	-4	-5	-6	-7	-8	-9	-10	-11	-12	-15



* Prediction accuracy decreases for distances less than 15 m from road centre.

TABLE 8

Effective Source Height of Road Traffic

Unadjusted Percentage of Heavy Trucks in Total Flow (%)	Effective Source Height (m)
0	0.5
1	1.0
2	1.2
3	1.3
4	1.4
5	1.5
6-7	1.6
8-9	1.7
10-11	1.8
12-14	1.9
15-17	2.0
18-21	2.1
22-25	2.2
26-30	2.3
>30	2.4

TABLE 9

Adjustment for Road Element Size: Reflective Surfaces

Subtended Angle ø (degrees)	Adjustment (dBA)	Subtended Angle ø (degrees)	Adjustment (dBA)
180	0	50	-6
160	-1	45	-6
140	-1	40	-7
120	-2	35	-7
100	-3	30	-8
90	-3	25	-9
80	-4	20	-10
70	-4	15	-11
60	-5	10	-13
55	-5	5	-16

TABLE 10

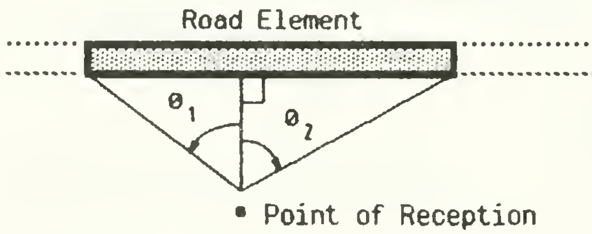
Angular Relationship between Road Elements and Receptor Locations

This table defines the angular relationship between a roadway element and a point of reception (observer) in terms of angles θ_1 and θ_2, expressed in degrees.

CASE 1

θ_1 is negative

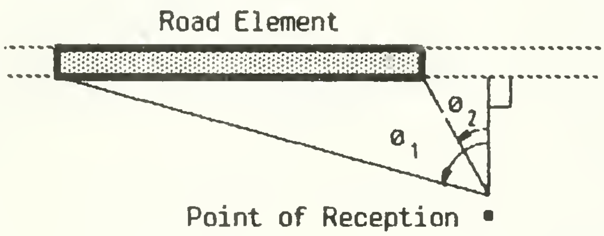
θ_2 is positive



CASE 2

θ_1 is negative

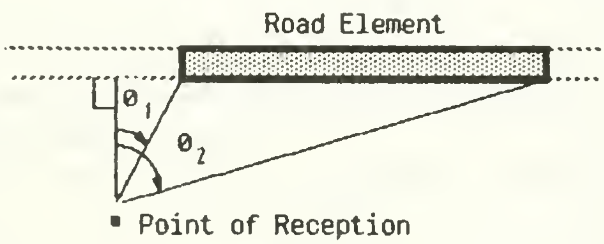
θ_2 is negative



CASE 3

θ_1 is positive

θ_2 is positive



SUBTENDED ANGLE of the road element at the point of reception:

$$\theta = \theta_2 - \theta_1$$

TABLE 11

Adjustment for Road Element Size: Non-Reflective Surfaces

LEFTMOST ROAD ANGLE, θ_l	RIGHTMOST ROAD ANGLE, θ_r -90	-80	-70	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70	80	90
	Adjustment in dBA																		
-90	-	-18	-14	-11	-9	-8	-7	-6	-5	-4	-4	-3	-3	-2	-2	-2	-1	-1	-1
-80	-	-	-16	-12	-10	-8	-7	-6	-5	-4	-4	-3	-3	-2	-2	-2	-2	-1	-1
-70	-	-	-	-14	-11	-9	-8	-6	-6	-5	-4	-4	-3	-3	-2	-2	-2	-2	-1
-60	-	-	-	-	-14	-10	-9	-7	-6	-5	-4	-4	-3	-3	-2	-2	-2	-2	-2
-50	-	-	-	-	-	-13	-10	-8	-7	-6	-5	-4	-4	-3	-3	-2	-2	-2	-2
-40	-	-	-	-	-	-	-13	-10	-8	-7	-6	-5	-4	-4	-3	-3	-3	-2	-2
-30	-	-	-	-	-	-	-	13	-10	-8	-7	-6	-5	-4	-4	-3	-3	-3	-3
-20	-	-	-	-	-	-	-	-	-13	-10	-8	-7	-6	-5	-4	-4	-4	-3	-3
-10	-	-	-	-	-	-	-	-	-	-13	-10	-8	-7	-6	-5	-4	-4	-4	-4
0	-	-	-	-	-	-	-	-	-	-	-13	-10	-8	-7	-6	-5	-5	-4	-4
10	-	-	-	-	-	-	-	-	-	-	-	-13	-10	-8	-7	-6	-6	-5	-5
20	-	-	-	-	-	-	-	-	-	-	-	-	-13	-10	-8	-7	-6	-6	-6
30	-	-	-	-	-	-	-	-	-	-	-	-	-	-13	-10	-9	-8	-7	-7
40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-13	-10	-9	-8	-8
50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-14	-11	-10	-9
60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-14	-12	-11
70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-16	-14
80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-18
90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 12

Adjustment for Pavement Surface Type

Pavement Surface Type	Adjustment (dBA)
Typical asphalt pavement such as HL-1	0
Open-graded friction course	-2.5
Dense-graded friction course	-1.5
Smooth concrete pavement	-1
* New concrete pavement, wire brush finish	+6
* Grooved concrete pavement	+7

* Not used on new highways

TABLE 13

Adjustment for Dense Woods and Rows of Houses

DENSE WOODS	
Depth of Woods between Source and Receiver (m)	Attenuation (dBA)
30	5
60	10
NOTE: Maximum attenuation allowed is 10 dBA	
FIRST ROW OF HOUSES	
Percentage of Row Occupied by Houses	Attenuation (dBA)
<40	0
40-65	3
65-90	5
>90	that of a barrier
ADDITIONAL ROWS OF HOUSES	
Apply attenuation of 1.5 dBA for each successive row up to a maximum of 10 dBA.	

TABLE 14

Addition of Sound Levels

Difference Between Higher and Lower Sound Levels (dBA)	To Obtain the Sum of Two Sound Levels, Add this Value to the Higher Level (dBA)
0	3.0
0.5	3.0
1.0	2.5
1.5	2.5
2.0	2.0
2.5	2.0
3.0	2.0
4.0	1.5
5.0	1.0
6.0	1.0
7.0	1.0
8.0	1.0
9.0	0.5
10.0	0
11.0	0
12.0	0
13.0 and up	0

APPENDIX B
CALCULATION OF BARRIER ATTENUATION

A "barrier" is any solid obstacle, natural or man made which interrupts the line of sight between the observer and the roadway.

Barriers include such items as elevated/depressed sections of roadway, large buildings, solid rows of townhouses, existing topographical features, earth berms, walls and fences. All of these obstructions may reduce noise generated by road traffic.

The following procedure is used to determine the attenuation of traffic noise provided by barriers of all types. This attenuation is commonly referred to as "barrier attenuation". The barrier is assumed to be parallel to the roadway and to obstruct the observer's view of the road. Calculations for finite and infinite length barriers are contained within this procedure.

STEP 1. Determine Barrier Extent

Determine ϕ_1 (the leftmost end angle of the barrier) and ϕ_2 (the rightmost end angle of the barrier). For Example, for infinite barriers ϕ_1 is -90° and ϕ_2 is +90.

STEP 2. Determine Finite Barrier Index

Determine the Finite Barrier Index (FBI) from Table B1, using the values of ϕ_1 and ϕ_2.

For example, FBI is 9 for an infinitely long barrier.

STEP 3. Determine Path Length Difference

Determine the Path Length Difference (PLD), according to the figure and formula shown in Table B2.

It must be noted that 'D_{SB}' and 'D_{BR}' are horizontal distances; therefore, the sum of D_{SB} and D_{BR} shall not be necessarily equal to the actual source-receiver separation distance.

Path Length Difference shall be calculated to an accuracy of at least 0.001 metres.

STEP 4. Obtain Barrier Attenuation

Determine the appropriate barrier attenuation* from Table B2, using the values of PLD and FBI.

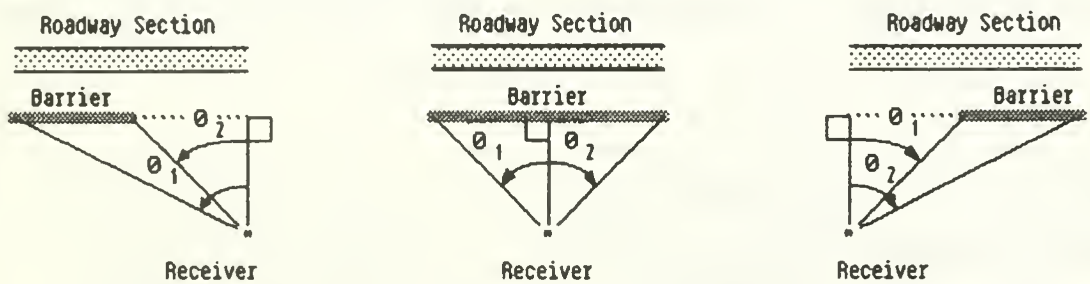
* The calculated barrier attenuation is accurate to $\pm$ 1.0 dBA, usually on the conservative side. The error in the barrier attenuation obtained from the table can be as high as 4 dBA for large values of PLD and acute angles of the barrier element. Such cases are: PLD greater than 4.0 m, $\emptyset_2-\emptyset_1$ less than 30° and $\emptyset_1$ less than -70° or $\emptyset_2$ more than +80°. In these circumstances the barrier attenuation could be under predicted by as much as 4 dBA. Nevertheless, this error has no appreciable influence on the overall result as the contributions from the remaining road elements dominate the resultant traffic noise level at the receiver.

TABLE B1

Finite Barrier Index for Asymmetric Barriers

θ_1, The Leftmost End Angle of the Barrier (degrees)	θ_2, The Rightmost End Angle of the Barrier (degrees)																	
	-80	-70	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70	80	90
-90	1	2	3	4	6	7	9	9	9	10	12	12	12	12	14	12	12	9
-80	-	5	8	10	10	14	15	15	18	18	19	19	19	19	19	19	18	12
-70	-	-	10	11	15	15	18	19	19	19	19	19	19	19	19	19	19	12
-60	-	-	-	15	18	19	19	19	20	20	20	20	20	20	20	19	19	14
-50	-	-	-	-	19	20	20	20	21	21	23	23	21	21	20	19	19	12
-40	-	-	-	-	-	20	21	23	23	23	23	23	23	21	20	19	19	12
-30	-	-	-	-	-	-	23	23	23	23	23	23	23	23	20	19	19	12
-20	-	-	-	-	-	-	-	23	23	23	23	23	23	23	20	19	19	12
-10	-	-	-	-	-	-	-	-	24	24	23	23	23	21	20	19	18	10
0	-	-	-	-	-	-	-	-	-	24	23	23	23	21	20	19	18	9
10	-	-	-	-	-	-	-	-	-	-	23	23	23	20	19	19	15	9
20	-	-	-	-	-	-	-	-	-	-	-	23	21	20	19	18	15	9
30	-	-	-	-	-	-	-	-	-	-	-	-	20	20	19	15	14	7
40	-	-	-	-	-	-	-	-	-	-	-	-	-	19	18	15	10	6
50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15	11	10	4
60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	8	3
70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	2
80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1

Angular Relationship between Barrier Sections and the Receiver



θ_1 is negative
θ_2 is negative

θ_1 is negative
θ_2 is positive

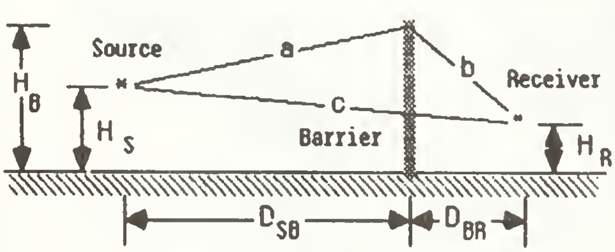
θ_1 is positive
θ_2 is positive

NOTES: 1) Where angles are not found in the table use the nearest listed value.

TABLE B2

Barrier Attenuation for Various Values of Finite Barrier Index

	Path Length Difference (m)	Finite Barrier Index																			
		1	2	3	4	5	6	7	8	9	10	11	12	14	15	18	19	20	21	23	24
		Barrier Attenuation (dBA)																			
Barrier does not interrupt the line of sight	0.34	3	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0.17	4	3	2	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
	0.07	5	4	4	4	4	3	3	3	2	2	2	1	1	1	1	1	1	1	0	0
	0.05	5	5	4	4	4	4	4	4	3	3	3	3	3	3	3	3	2	2	2	1
	0.03	5	5	5	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	3	3
	0.02	5	5	5	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
	0.00	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Barrier Does Interrupt the Line of Sight	0.03	5	5	5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	7
	0.10	5	6	6	6	6	7	7	7	7	7	7	7	7	8	8	8	8	8	9	9
	0.17	6	6	7	7	7	7	7	7	8	8	8	8	8	9	9	9	9	10	10	11
	0.24	6	6	7	7	7	8	8	8	9	9	9	9	9	9	10	10	10	11	11	12
	0.28	6	7	8	8	8	9	9	9	9	9	9	10	10	10	10	11	11	12	12	12
	0.34	6	7	8	8	8	9	9	9	10	10	10	10	10	11	11	12	12	13	13	13
	0.52	7	8	8	9	9	10	10	10	11	11	12	12	12	12	13	13	14	14	14	15
	0.69	7	8	9	10	10	10	11	11	12	12	13	13	13	13	14	14	15	15	16	16
	1.03	8	9	10	11	12	12	12	13	13	14	14	14	15	15	15	16	17	17	18	18
	1.38	9	10	11	12	13	13	13	14	14	15	15	15	16	16	17	17	18	18	19	19
	1.70	9	11	12	13	14	14	14	15	15	16	16	16	17	17	18	18	19	19	20	20
	2.06	10	11	13	14	14	14	15	16	16	16	16	16	17	18	18	19	20	20	20	20
	2.75	11	13	14	15	15	15	16	16	16	17	17	17	18	19	19	19	20	20	20	20
	3.44	11	13	14	15	16	16	16	17	17	18	18	18	18	19	19	20	20	20	20	20
	5.16	12	14	15	16	17	17	17	18	18	18	18	18	19	20	20	20	20	20	20	20
	6.88	13	15	16	17	17	18	18	18	18	19	19	19	19	20	20	20	20	20	20	20



Barrier, Source and Receiver Configuration

$$PLD = a + b - c$$

Where

$$a = \sqrt{D_{SB}^{\,2} + (H_B - H_S)^2}$$

$$b = \sqrt{D_{BR}^{\,2} + (H_B - H_R)^2}$$

$$c = \sqrt{(D_{SB} + D_{BR})^2 + (H_S - H_R)^2}$$

NOTE: 1) Where the calculated PLD is not found in the table use the nearest listed value.

APPENDIX C

COMPUTATION OF $L_{EQ}(T)$

(BASED ON DAILY TRAFFIC VOLUMES)

In the planning of noise sensitive developments or of projects such as roads or industries, dependent on the application, traffic sound levels must be determined: (a) over a 24-hour period; (b) over a day or night time period or (c) on an hourly basis.

In many cases, the provincial/municipal traffic department may not be able to provide traffic data based on surveys conducted over specific time periods of the 24-hour day.

The following describes the method which may be used to determine the equivalent sound level, L_{eq}, due to road traffic over various time periods of the 24-hour day using the information on average daily traffic provided by the road authority.

1. Information Requirements

The road authority should be contacted for the following data:

(a) Average Annual Daily Traffic Volume (AADT) and when available the Summer Average Daily Traffic Volume (SADT); use the higher of AADT or SADT;

(b) Composition of traffic, i.e. the percentage of vehicles classified by the model as automobiles, medium trucks and heavy trucks; and

(c) Posted Speed Limit (km/h)

Future traffic volumes should be based on traffic projections at least 10 years after completion of the project or the ultimate capacity indicated by the road authority.

2. Method of Calculation

2.1 Method 1: Through Adjustments made to Existing/Future Traffic Volumes

Since the model predicts the equivalent sound level, L_{eq}, due to road traffic over a 1-hour time period, the average daily traffic volume (higher of AADT or SADT) must be reduced to a one-hour volume for the time period considered.

The following one-hour traffic volumes (existing/future) must be employed in calculating:

(a) Daily Sound Level (24-hours)

$$\text{volume (1 hr)} = \frac{\text{avg. daily volume}}{24}$$

(b) Daytime Sound Level (07:00 to 23:00)

$$\text{volume (1 hr)} = \frac{\text{avg. daily volume}}{16} \times T_D$$

Where: T_D = fraction of daily volume during daytime period

(c) Night-time Sound Level (23:00 to 7:00)

$$\text{volume (1 hr)} = \frac{\text{avg. daily volume}}{8} \times T_N$$

Where: T_N = fraction of daily volume during nighttime period

(d) Hourly Sound Level

$$\text{volume (1 hr)} = \frac{\text{avg. daily volume}}{1} \times T_H$$

Where: T_H = fraction of daily volume during a one hour period

When determining the traffic sound levels over various periods of the 24-hour day, the user must, of course, employ the estimated percentage of cars, medium trucks and heavy trucks which occur during the period under consideration.

2.2 Method 2: Through Adjustments made to Sound Levels - L_{eq} (24 hr)

This method may be used to determine the equivalent sound level, L_{eq}, due to road traffic over different time periods provided the traffic composition during the period under consideration does not vary greatly from the composition averaged over the entire 24-hour day.

(1) Adjustment for Period of Day

Once the existing/future traffic sound level, L_{eq} (24 hr), has been determined the following expression may be used to obtain:

(a) L_{eq} (16 hr) = Daytime Sound Level

$$L_{eq}\ (16\ hr) = L_{eq}\ (24\ hr) + 10\ Log\ (24/16) + 10\ Log\ (x)$$

(b) L_{eq} (8 hr) - Nighttime Sound Level

$$L_{eq}\ (8\ hr) = L_{eq}\ (24\ hr) + 10\ Log\ (24/8) + 10\ Log\ (x)$$

(c) L_{eq} (1 hr) - Hourly Sound Level

$$L_{eq}\ (1\ hr) = L_{eq}\ (24\ hr) + 10\ Log\ (24) + 10\ Log\ (x)$$

In the above expressions,

x = fraction of daily volume during the period considered

(2) Adjustments for Future Sound Levels

The future sound level, $L_{eq}(T)$, for any time period T of the 24-hour day may be obtained through application of an adjustment (in decibels) to the existing sound level.

The future sound level is given by the expression:

$$L_{eq}(T)_F = L_{eq}(T)_E + 10 \operatorname{Log} (1 + R)^N$$

Where:

R = Annual rate of change in traffic volume (a fraction)

N = Projected time period (in years)

The above method for determining future sound levels may be used only if there is no significant difference between the fraction of the existing daily traffic volume and that of the future daily traffic volume for the period of the 24-hour day under consideration.

3. Examples of Typical Variations in Traffic Sound Levels During the Day and Night Time Period

(a) Arterial Roads

On most arterial roads the major portion of the daily (24 hour) traffic volume, about 90%, tends to occur during the daytime period (07:00 to 23:00).

The following expressions indicate the approximate relationships between the equivalent sound levels over the day/night time periods and the 24-hour equivalent sound level.

$$L_{eq}\ (16\ hr) = L_{eq}\ (24\ hr) + 1 \qquad \text{(day)}$$

$$L_{eq}\ (8\ hr) = L_{eq}\ (24\ hr) - 5 \qquad \text{(night)}$$

(b) Highways

The typical split between traffic volumes during the day and night time periods on highways is about 85% (day) and 15% (night).

The equivalent sound levels for these respective time periods are given by:

$$L_{eq}\ (16\ hr) = L_{eq}\ (24\ hr) + 1 \qquad \text{(day)}$$

$$L_{eq}\ (8\ hr) = L_{eq}\ (24\ hr) - 3.5 \qquad \text{(night)}$$

(c) Freeways (Controlled Access)

On sites adjacent to most freeways no significant differences are considered between the equivalent sound levels measured over the 16 hour daytime and 8 hour nighttime periods.

The future sound level is given by the expression:

$$L_{eq}(T)_F = L_{eq}(T)_E + 10 \text{ Log } (1 + R)^N$$

Where:

R = Annual rate of change in traffic volume (a fraction)

N = Projected time period (in years)

The above method for determining future sound levels may be used only if there is no significant difference between the fraction of the existing daily traffic volume and that of the future daily traffic volume for the period of the 24-hour day under consideration.

3. Examples of Typical Variations in Traffic Sound Levels During the Day and Night Time Period

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On most arterial roads the major portion of the daily (24 hour) traffic volume, about 90%, tends to occur during the daytime period (07:00 to 23:00).

The following expressions indicate the approximate relationships between the equivalent sound levels over the day/night time periods and the 24-hour equivalent sound level.

$$L_{eq} \text{ (16 hr)} = L_{eq} \text{ (24 hr)} + 1 \qquad \text{(day)}$$

$$L_{eq} \text{ (8 hr)} = L_{eq} \text{ (24 hr)} - 5 \qquad \text{(night)}$$

(b) Highways

The typical split between traffic volumes during the day and night time periods on highways is about 85% (day) and 15% (night).

The equivalent sound levels for these respective time periods are given by:

L_{eq} (16 hr) = L_{eq} (24 hr) + 1 (day)

L_{eq} (8 hr) = L_{eq} (24 hr) - 3.5 (night)

(c) Freeways (Controlled Access)

On sites adjacent to most freeways no significant differences are considered between the equivalent sound levels measured over the 16 hour daytime and 8 hour nighttime periods.

APPENDIX D
TRAFFIC NOISE
PREDICTION WORK SHEET

TRAFFIC NOISE PREDICTION WORK SHEET

Name ____________ Date ____________ File ____________ Project Description ______________________________

1	Lanes/Road Section (Element)								
2	Volume -Automobiles (vph)	S 2.2(a)							
3	Medium Trucks (vph)								
4	Heavy Trucks (vph)								
5	Total Volume (vph)								
6	Posted Speed (km/h)								
7	Heavy Trucks (%)								
	Adjusted Heavy Trucks	S 2.2(b)							
8	Road Gradient (%)								
9	Adjustment Factor	Table 1							
10	Adjusted Volume (vph)								
11	Medium & Heavy Trucks (%)	S 2.2(c)							
12	Medium Trucks (%)	S 2.2(d)							
13	Reference Sound Level (dBA)	Tables 3-6							
	Effective Heights								
14	Source (s) (m)	Table 8							
15	Receiver (r) (m)								
16	Shielding (t+p) (m)	Table 7							
17	Total Effective Height (m)	Table 7							
	Adjustments								
18	Volume (dBA)	Table 2							
19	Distance (m)								
20	Reflective (dBA)	Table 7							
21	Non-reflective (dBA)	Table 7							
22	Element, θ 1 (degrees)								
23	θ 2 (degrees)								
24	Reflective (dBA)	Table 9							
25	Non-reflective (dBA)	Table 11							
26	Pavement Surface (dBA)	Table 12							
27	Woods (dBA)	Table 13							
28	Rows Of Houses (dBA)	Table 13							
	Barrier Shielding								
29	θ 1 (degrees)								
30	θ 2 (degrees)								
31	Finite Barrier Index	Table B1							
32	Path Length Difference (m)	Table B2							
33	Barrier Attenuation (dBA)	Table B2							
34	Section Leq(h) (dBA)								
35	Road Leq(h) (dBA)	Table 14							